THIN SHEET MIRROR AND Nd_2O_3 DOPED GLASS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application, Serial Number 60/255,759, filed December 15, 2000 entitled Thin Sheet Mirror and Nd_2O_3 Doped Glass of Ronald L. Stewart.

FIELD OF THE INVENTION

[0002] A reflecting mirror comprising a thin sheet of glass, and an alkali metal-zinc-borosilicate glass doped with neodymium oxide (Nd2O3) and adapted to be drawn in the form of a thin sheet.

BACKGROUND OF THE INVENTION

[0003] Thin sheet glass, commonly referred to as microsheet, is well known in the glass art. The glass sheets have a thickness less than 0.5 mm, a standard thickness being in the range of 0.3 to 0.4 mm. Microsheet glass is used for such diverse purposes as protective covers for satellite solar cells, laptop LCDs, and glass-plastic laminates.

[0004] Mirrors are commonly produced by applying a highly reflecting film or coating of, for example, silver or aluminum, over one flat surface of a glass sheet. Light rays pass through the glass sheet and are reflected back to create the familiar image. Thus, the effective light path in the glass sheet is twice the thickness of the glass sheet.

[0005] The present invention is particularly concerned with a rearview mirror such as used in vehicular transport means on sea, on land, or in the air. A problem of long standing is that of visual discomfort, and loss of object definition, created by reflection of certain radiation. The reflection of illumination from a mirror, particularly at night, can be particularly serious. This has led to special mirrors that can be tilted at night. A similar effect occurs with reflected sunlight, especially when the sun is just rising or setting.

[0006] It has been reported that this problem largely arises from a relatively narrow portion of the spectral energy distribution in light reflected by a mirror. In terms of color, this is the yellow region which lies primarily between wavelengths of 565 and 595 nm. The red, green and blue regions, which lie outside this wavelength range, appear to provide little or no contribution to the problem.

[0007] It is then a primary object of the present invention to provide a reflecting mirror that is improved with respect to the visual discomfort and object blurring that tends to occur with reflected illumination and sunlight.

[0008] It is another object to provide a glass that removes, in part at least, the yellow color region in reflected light.

[0009] It is a further purpose to provide this selective color effect in glass of microsheet thickness.

[0010] It is still another purpose to provide a glass having this desired color absorption effect, in conjunction with viscosity properties that enable the glass to be drawn as microsheet, that is in a thickness less than 0.5 mm.

SUMMARY OF THE INVENTION

[0011] The invention resides in part in a reflective mirror comprising a sheet of alkali metal-zinc-borosilicate glass bonded to a reflecting surface, the glass having a thickness less than 0.5 mm and being doped with Nd_2O_3 in an amount sufficient to reduce the spectral transmission in the range of 565-595 nm.

[0012] The invention further resides in a sheet of an alkali metal-zinc-borosilicate glass containing sufficient Nd_2O_3 in its composition to reduce the transmission of 585 nm wavelength to less than 50% in a 0.6 mm path length.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIGURE 1 in the drawing is a side sectional view of a rear view mirror constructed in accordance with the present invention.

[0014] FIGURE 2 is a graphical representation illustrating a significant property of Nd_2O_3-doped microsheet in accordance with the invention.

DESCRIPTION OF THE INVENTION

[0015] The present invention provides a reflecting mirror, particularly a rearview mirror, in which the visual discomfort and blurring, caused by reflected illumination or sunlight, are alleviated. Such mirrors are widely used in all types of transport vehicles. However, the problem is particularly prevalent in rearview mirrors for automotive vehicles. Accordingly, the invention is described with respect to such application.

[0016] FIGURE 1 is a side elevational view of a typical rearview mirror embodying the invention, and generally designated 10. Mirror 10 comprises a standard casing or enclosure 12 and a microsheet glass member 16 having a reflecting surface 14, e.g. a silver film on its rear surface. Glass member 16 may be bonded to casing 12 in known manner. One such structure is shown in United States Patent No. 5,566,031 ( ).

[0017] The present invention is largely concerned with microsheet glass member 16. As pointed out earlier, microsheet glass is less than 0.5 mm in thickness. For present purposes a thickness of about 0.3 mm is employed. Since reflected light traverses glass twice, the effective light path is about 0.6 mm. Accordingly, transmission data shown hereafter was measured on glass samples having a thickness of 0.6 mm.

[0018] It has been found that yellow light, that is spectral radiation having a wavelength within the range of 565-595 nm, is the primary cause of the visual discomfort and blurring. It has further been found that doping a glass with up to 20% Nd_2O_3 will effectively diminish radiation in this yellow region. Surprisingly, and fortunately, the remaining portions of the visible part of the spectrum have little tendency to cause eye discomfort and blurring.

[0019] Any amount of Nd_2O_3 doping has some effect, on suppressing the radiation at yellow wavelengths. However, to have a substantial effect, at least about 5% is required. By substantial is meant reduction of the radiation at a wavelength of about 585 nm to a value under 50%.

[0020] Conventional sheet glass used in mirrors has a thickness in the range of 0.5-4.0 mm, usually about 2 mm. Such sheet glass may be produced by well known rolling or drawing procedures. Accordingly, it is customary to employ a soda lime

silicate glass. This may be modified by other divalent metal oxides for special effects.

[0021] The production of thinner microsheet glass requires special processing. For present purposes, a special mechanism, known as a slot draw, is employed. One family of glasses successfully slot drawn into microsheet has an alkali metal-zinc-borosilicate base glass. It has been found that Nd_2O_3 does not tend to readily stay dissolved in this base glass. In other words, the glass tends to devitrify with Nd_2O_3 crystals separating in the glass.

[0022] This prohibitive tendency can, and must, be avoided by carefully choosing the base glass components and the amounts in which they are present. This will become apparent in a subsequent composition TABLE.

[0023] In general, it has been found necessary to use lower B_2O_3 content while employing a higher range content of alkali metal oxides (R_2O) when the Al_2O_3 content is over about 2.5%.

[0024] At the same time, microsheet drawing imposes some property limitations that must be observed. In general, these involve glass viscosity versus temperature behavior of a glass melt. In particular, the viscosity at the liquidus temperature must be maintained equal to, and preferably above, 20,000 poises. At the same time, the softening temperature of the glass must be maintained in the range of 700-750° C. In the TABLE below, several glass compositions are set forth in weight percent on an oxide basis. These compositions, including comparative examples 7 and 8 which devitrified, illustrate the care that must be taken in compounding a suitable glass composition.

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Glass	1	2	3	4	5	6	7	8	9	10	11	12
Oxide (wt. %)												
SiO_2	65.6	64.3	62	60	60	60	60	60	63	57	57	58
Al_2O_3	2.25	2.25	2.25	4.25	2.25	2.25	4.25	4.25	2.25	2	2	2.25
Na_2O	7.15	7.15	7.15	7.15	5.15	5.05	4.15	6.5	6.5	7.15	6	6.5
B_2O_3	11.1	11.1	13.4	13.4	13.4	13.5	13.4	14	14	11.1	11.1	13
K_2O	6.65	3.9	3.9	3.9	3.9	3.9	2.9	0	0	5.5	7.65	5
ZnO	7	7	7	7	7	5	5	4	4	7	6	7
Sb_2O_3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Nd_2O_3	0	4	4	4	8	8	10	11	10	10	10	8
Property												
Density										2.707	2.686	2.639
CTE ppm	7.3	6.74	6.62	6.59	6.05	6.08			5.27	7.69	7.81	7.43
Tanneal C	554	556	553	545	555	551			566	557	559	554
Tstrain C	514	517	515	508	517	511			528	518	519	515
Tsp C	748	736	730	715	728	740			751	716	724	714
Liq T (24 hr) C										960	960	960
Liq Visc kP										12	17	14
Crystal										Nd_2O_3	Nd_2O_3	Nd_2O_3

Glass	13	14	15	16	17	18	19	20	21	22	23	24
Oxide (wt. %)												
SiO_2	58.5	60	58	55	55	55	57	57	57.8	57	57	58
Al_2O_3	2	2	2.25	6	6	6	2	2	2	2.5	2.5	2.5
Na_2O	5.4	5.4	5.2	6.2	4.45	6.75	7.15	7.15	7	9.25	8.25	7.75
B_2O_3	12.85	11.1	13.4	11.65	13.4	12	8	8	7	6	6	6
K_2O	4	4.25	4.9	4.9	5.9	4	8.6	7.6	7	8	8	6.5
ZnO	7	7	7	7	7	6	7	8	9	7	8	9
Sb_2O_3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Nd_2O_3	10	10	9	9	8	10	10	10	10	10	10	10
Property												
Density												
CTE ppm												
Tanneal C												
Tstrain C												
Tsp C												
Liq T (24 hr) C	1060	1060	1030	1090	1085	1115	930	955	905	955	910	<670
Liq Visc kP							42	23	55	34	65	>1000
Crystal	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	Nd_2O_3	none

[0025] Glass batches were prepared from standard ingredients including sand, alumina, zinc oxide, antimony oxide and Nd_2O_3. Boric acid and/or sodium borate were used as a source of B_2O_3. The alkali metals were added as nitrates or carbonates, or as sodium borate.

[0026] The batches were mixed in conventional manner and melted at 1550° C. As noted earlier, glass samples were prepared by grinding and polishing molded blanks to a thickness of 0.6 mm, for making measurements of transmission. Regular blanks were obtained for physical property measurements in accordance with conventional procedures.

[0027] FIGURE 2 is a graphical representation comparing the optical transmission curves for 0.6 mm thick glass samples having compositions 1, 5 and 9 in the TABLE above. A 0.6 mm sample is used to correspond to the double passage of radiation in a 0.3 mm thick glass mirror.

[0028] The significant feature of the transmission curves, for present purposes, is the steep drop in transmission in the yellow portion of the spectrum, that is the portion between 565 and 595 nm. Curve A represents composition 1 which contains no Nd_2O_3. This is a typical transmission curve for a non-absorbing, transparent glass containing no colorant or absorbing additive. It shows a steady transmission of slightly over 90% at wavelengths between 380 and 750 nm. In contrast, Curve B is the corresponding transmission curve for the glass sample having composition 5. The transmission of this glass, which contains 8% Nd_2O_3, drops steeply in the yellow region to a low value of about 27% at 585 nm. Likewise, Curve C, based on measurements made on a glass having composition 9, shows a somewhat greater drop to a minimum transmission of about 20% at 585 nm.

[0029] Comparison glasses, having compositions 7 and 8, devitrified before a 6mm thick patty cooled from each melt poured on a steel plate. The crystals formed were precipitated Nd_2O_3. This indicates that the present glasses tend to be unstable as the amount of Nd_2O_3 dopant is increased. The transmission curves of FIGURE 2 indicate the desirability of increased Nd_2O_3 contents however.

[0030] To accommodate larger amounts of Nd_2O_3, the base glass must then be adjusted to enhance Nd_2O_3 solubility. At the same time, physical property control must be maintained to permit drawing of glass having microsheet thickness. To this

end, the liquidus viscosity must be at least 20,000 poises and preferably higher. Also, the softening point of the glass must be maintained at 700 to 750° C.

[0031] From the liquidus data thus far obtained that are listed in the Table, it appears that the lower Al_2O_3 and B_2O_3 levels tend to permit the Nd_2O_3 to remain in solution. The glass is stiffened by decreasing the B_2O_3 level. This effect can be compensated by concomitant increase of the alkali metal oxides of sodium and potassium along with reducing Al_2O_3. The content of ZnO may also be increased somewhat, and with similar the levels of the alkali oxides the glass softening temperature can be further reduced.

[0032] In general then, a suitable glass composition will essentially consist, in weight percent on the oxide basis, of:

SiO_2	55-70%
Al_2O_3	0.5-4.5%
B_2O_3	6-14%
ZnO	3-10%
Na_2O	5-11%
K_2O	2-9%
Na_2O+K_2O	7-20%
Nd_2O_3	at least 5%